

REMARKS

The Final Office Action mailed January 22, 2004, has been reviewed and carefully considered. Claim 10 has been amended mainly for the purpose of clarification. Claims 11-13 have been cancelled. No new matter has been added. Claims 10 and 14-21 remain pending in this application, with claim 10 being the only independent claim.

Claims 10-12 and 14-21 have been rejected. Reconsideration of the above-identified application, as amended, and in view of the following remarks is respectfully requested.

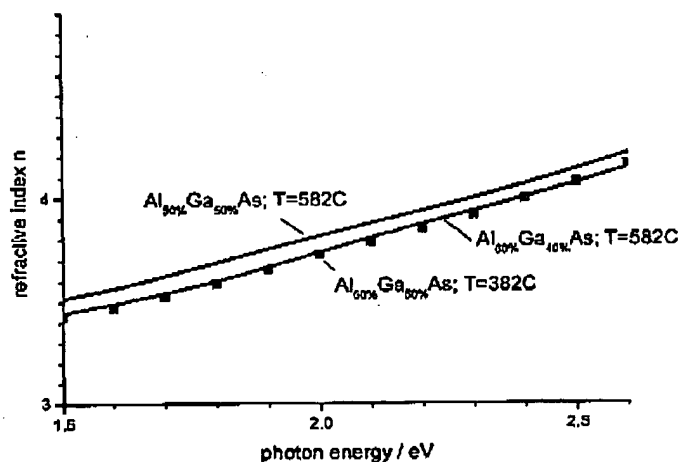
In the outstanding final office action, the Examiner repeated his rejections of claims 10-12 and 14-21 as unpatentable under 35 U.S.C. §103(a) over Sugawara et al. (U.S. Patent No. 4,203,799) in view of Case (US Patent 4,555,767).

Applicants submit that the Examiner correctly assumed that the term "Fabry-Perot-oscillations" is functionally identical to the use of a standard interference waveform generated by light waves reflecting off various surfaces of a multi-element material. However, the examiner derived at an incorrect conclusion. The present invention performs reflectance measurements in the visible range of the light spectrum (1.5 ... 5.0 eV or ~240 nm ...~800 nm). This means that the invention utilizes a simple and relatively inexpensive measurement technique.

More specifically, the method of the present invention provides a measurement of the reflectivity of a layer. The reflectivity oscillates during the growth of the layer. These oscillations comprise minima and maxima. It was found that - when a binary crystalline material (e.g., AlAs) is grown on a substrate formed by another binary material (e.g. GaAs) it is possible to directly (without any numerical analysis or calculation) derive the parameter (such as temperature) characteristic of the layer from an extremum (minimum or maximum) of the reflectivity of a layer when the layer is illuminated with a constant amount of illuminating energy. In contrast, the Sugawara reference and the Case reference do not provide such direct way, neither alone or in combination. Accordingly, these references do not render the present invention obvious.

The present invention utilizes binary materials (consisting of only two types of atoms), and thus, no composition artefacts to the temperature measurement will occur. As applicants provided Fig. 3, the depth of the minimum during the AlAs growth (0...280 sec) can be directly translated into the actual wafer temperature (a minimum of 0.4 directly results into 600 °C)

with an accuracy better than 5 degrees. Further, in Fig. 11 of the present specification, the depth of the ALAs minimum is 0.4 and hence a wafer temperature of 600C is measured. At the right-hand side of the same figure one can see the Fabry-Perot oscillation of the ternary AlGaAs material. For this ternary AlGaAs material (consisting of three types of atoms), the accurate measurement from the analysis of the Fabry-Perot oscillation (between 700 and 900 sec), which is a very important technological issue. It is the refractive index of AlGaAs that changes with composition and that causes the respective change of the Fabry-Perot-oscillation with composition. But the refractive index also changes with temperature. Accordingly, it is the accurate real-time measurement of the wafer temperature performed before (between 0 ... 280sec) that opens the way for accurate composition measurement! To illustrate this we prepared the following figure:



Starting from a given composition and temperature (50% Al at $T=582^{\circ}\text{C}$) the same shift in refractive index can be caused by composition change (to 60% Al) or by temperature change (to 382°C)! Hence: an accurate composition measurement through the refractive index is only possible when the temperature is well known!

The same holds for accurate growth rate measurements. The period of a Fabry-Perot oscillation is defined by the product $n \cdot d$ of refractive index n and the thickness d . If n is incorrectly assumed, because the temperature is not exactly known, than the resulting growth rate is incorrect.

Applicants submit that Sugawara does not measure reflectivity at all. In contrast to the present invention, it is the thermal radiation from the wafer that is being measured, which also oscillates. Therefore, Sugawara does not disclose any illumination of the layer. From the oscillations

in the thermal radiation from the wafer in the Sugawara reference, the thickness of the epitaxial layer is monitored. An additional contrast to the present invention is provided in that the determination of the thickness of the layer is made with the assumption of an approximated temperature. For both reasons the accuracy is very low in comparison with the present invention where reflectance of visible light is used and the temperature is determined precisely. And with the knowledge of the precise temperature the growth rate is determined at much higher accuracy. The same hold for the composition measurement.

Case can not remedy the missing disclosure of Sugawara. In Case, a reflectivity measurement is disclosed which is used for the determination of the growth rate. In difference to the present invention, however, Case uses far infrared radiation which results in a low variability of the refraction index with the temperature. Therefore the influence of the temperature for determination of the growth rate is relatively low. However, due to the much longer wavelength used (up to 10000nm), the measurement of the Case reference achieves an accuracy of only appr. 100 nm. In contrast, the present invention achieves an accuracy of appr. 1nm. Moreover, the refractive index in the infra-red of Case is much less sensitive to the composition and therefore already for this reason can not be used for accurate composition measurements. Most importantly, no temperature measurement can be derived from the IR reflectance (the IR refractive index simply does not change sufficiently with temperature) - and this is the key result of the present invention.

For the foregoing reasons applicants submit that independent claim 10 as amended to more clearly claim the invention, is patentable over the art of record. Claims 14-21 depend directly or indirectly from independent claim 10 and thus are patentable for the same reasons that claim 10 is patentable. Applicants submit that the application is now in condition for allowance and passage to issuance is requested.

If any additional fees or charges are required at this time in connection with the application, authorization is hereby given to charge our Patent and Trademark Office Deposit Account No. 14-1263.

Respectfully submitted,



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